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Brockway

A Strategy for Planning and Implementation of Ecosystem Management

by Dale G. Brockway

A STRATEGY FOR PLANNING AND IMPLEMENTATION OF

ECOSYSTEM MANAGEMENT

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ECOSYSTEM MANAGEMENT

Historical Background

Development of the Concept

The ecosystem concept as an integrated unit of living organisms together with their inorganic environment was first reported by Arthur Tansley (1935). A plan adopted by the Ecological Society of America in 1932 recognized that the national nature sanctuary system must protect a wide variety of ecosystem types as well as particular species of concern (Shelford 1933). This plan was also the first to appreciate the importance of management that considered the fluctuations of natural disturbances and propose the core reserve/buffer zone approach. Two Park Service biologists, Wright and Thompson (1935), were the first to observe that the National Parks were of areas too limited to serve as fully functional ecosystems and advocated that park sizes be increased. Aldo Leopold (1949) also applied the ecosystem concept to conservation science and philosophy. However, these early attempts to base resource management more firmly upon ecological science were largely unsuccessful.

In recent decades, Caldwell (1970) advocated using ecosystems as the basis for managing public lands; however, the environmental movement of that time lacked the necessary political influence to institute such change. Numerous writings since have reinforced the notion that ecosystems could serve as an important fundamental basis for managing natural resources (Craighead 1979, Newmark 1985, Clark and Zaunbrecher 1987, Clark and Harvey 1988, Friedman 1988, Grumbine 1988, Keiter 1989, 1990). The first ecosystem management book discussed goals and a process for attainment framed within a dynamic pattern-and-process model of nature (Agee and Johnson 1988). Ecologically defined boundaries, clear management goals, interagency cooperation, monitoring results, national policy leadership and recognition of humans as an integral part of ecosystems were identified as essential components. The authors concluded that since what is natural cannot be scientifically resolved, management goals must rest on achieving socially desirable conditions.

The first interagency attempt to apply ecosystem management on federal lands (Greater Yellowstone Coordinating Committee 1990) fell victim to intense political debate (Grumbine 1994). The following year, California was first to address biological impoverishment through a policy based largely on ecosystem management (State of California 1991). One year later in a major policy move, the Forest Service adopted ecosystem management as an evolutionary refinement of its traditional multiple-use mandate (USDA Forest Service 1992). This change in policy was preceded from 1990 to 1992 by the new perspectives pilot program, which incorporated into the Forest Service an increasing appreciation for ecological science, improved cooperation with the public through formation of planning and management partnerships and greater operational efficiencies in the conduct of agency business.

Evolution of Public Views

Prior to the late 19th century, over-exploitation of natural resources was relatively commonplace, owing to the public perception that America was a land of boundless bounty. Near century's end, the American frontier closed and public perception began to change, becoming increasingly concerned about potential resource shortages. Out of this concern was born the conservation movement, a movement of revolutionary scope which lead to creation of new government agencies and passage of resource management laws. Conservation was based on a utilitarian philosophy which disparaged unbridled exploitation, replacing it with regulated consumption of resources at rates that allowed retaining sufficient quantities for future use. Gifford Pinchot, first chief of the Forest Service, was an early champion of conservation. During this same period, a contrasting preservation philosophy and movement simultaneously developed, based upon the writings of John Muir. These two contrasting views served as a basis for the subsequent decades of debate concerning use of natural resources in the best interest of the American public.

In the late 1940s and 1950s, housing demand from a rapidly growing population resulted in increasing levels of timber harvest from national forest lands. By 1960, the Forest Service had refined earlier conservation into a mandate for multiple-use, being responsive to increasing public demands for a wide range of natural resource uses on national forest lands. During the 1960s and 1970s, increasing recreational use of national forest lands and continuing research progress in the ecological sciences fostered in the American public a growing appreciation for the natural world. An increasing appreciation of nature and a growing awareness that resources had finite limitations precipitated yet another perceptual shift in the public mind that culminated in the birth of the environmental movement. Some members of this movement represented preservationist views, while others who believed in wise use were troubled by wide-spread environmental degradation and still others simply could not reconcile certain management approaches with their personal values.

During the 1970s and 1980s, the political influence of the environmental movement steadily grew as increasing numbers of the public became concerned about the quality of their environment and the habitats and populations of other species. This movement supported enactment of numerous environmental protection laws which at times conflicted with the utilitarian view of resource management. The accelerating biodiversity crisis (Noss and Cooperrider 1994), continuing environmental deterioration (Soule' 1991), development of conservation biology theory and practice (Grumbine 1994), continuing population growth and industrial development (Doermus 1991), increasing litigation challenging current resource management practices (Grumbine 1992) and unfulfilled expectations for meaningful participation in agency decision-making (Grumbine 1994) lead to changing public views about society's relationship with nature (Dunlap and Mertig 1992). By the early 1990s, over 90 percent of Americans polled described themselves as supportive of the aims of environmental protection. This expressed view, in combination with the growing body of scientific information related to the importance of ecological structures and processes, contributed to the Forest Service adopting a policy of ecosystem management. Thus, agency paradigms have shifted in response to changing perceptions and values in the larger society.

National Direction

Definition

Ecosystem management will be the fundamental policy guiding all future Forest Service management and research activities (USDA Forest Service 1992). As defined in the initial policy statement:

> "Ecosystem management means using an ecological approach to achieve multiple-use management of national forests and grasslands by blending the needs of people and environmental values in such as way that the national forests and grasslands represent diverse, healthy, productive and sustainable ecosystems."

New Philosophy

Ecosystem management represents both a new philosophy (i.e., a new way of thinking about ecosystems and their resources) and a new approach to management (i.e., the development of plans and implementation of programs and projects from a holistic perspective that emphasizes stewardship and wise use). It means the use of skill and care in managing integrated units of organisms and their environments. It implies that the ecosystem (i.e., integrated ecological unit) is the context for management rather than just its individual parts. Sustaining the viability of ecosystems is central to both the philosophy and approach that managers will undertake.

Maintaining ecosystem health is of key importance. This will be accomplished through integration of the best scientific information into the management decision-making process, so that levels of use by humans remain compatible with maintaining the compositional, structural and process elements of the ecosystem. Analysis will be conducted that looks beyond the local level to comprehensively assess information needs and likely effects of actions at landscape scales and multiple time scales. Addressing the needs of people is an integral part of ecosystem management. It is therefore vital that shared expectations for the ecosystems on public land be developed through effective participation of all interested and affected publics.

Emerging Themes, Goals and Principles

Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long-term (Grumbine 1994). While consensus concerning ecosystem management continues to develop, several widely cited dominant themes have emerged.

(1) Hierarchical Context: A systems perspective is required which addresses management issues within an ecological hierarchy of multiple scales, with interconnection among all levels.

(2) Ecological Boundaries: Ecosystem management requires management of ecological units and issues that transcend administrative boundaries.
(3) Ecological Integrity: Ecosystem management requires protecting native diversity and the ecological patterns and processes that maintain that diversity, including viable populations, natural disturbance regimes and representation of ecosystems across natural ranges of variation.
(4) Data Collection: Ecosystem management requires increased research data collection concerning baseline conditions, disturbance regimes and classification and inventories and improved management of existing data.
(5) Monitoring: Tracking the results of management actions is an essential feedback loop of information useful in updating management practices.
(6) Adaptive Management: Recognizing the tentative nature of all scientific knowledge, management treatments are regarded as operational experiments designed with feedback which allows for adjustment to uncertainty.
(7) Interagency Cooperation: Managing ecological units and issues across administrative boundaries requires cooperation among management agencies as well as between agencies and private partners.
(8) Organizational Change: The broader focus of ecosystem management requires change in operational procedures, professional norms and power relationships.
(9) Humans Embedded in Nature: Humans are an integral part of nature that influence and are influenced by ecological process and structures.
(10) Values: Human values have a dominant influence upon establishing and achieving ecosystem management goals.

The major goals of ecosystem management focus upon ultimately eliminating the various environmental crises which confront us and establishing a role for humans that is sustainable within the productive capacity of ecosystems.

(1) Maintain viable populations of all native species.
(2) Maintain representation of all native ecosystem types across their natural range of variation.
(3) Maintain evolutionary and ecological processes, such as disturbance regimes, energy flows, nutrient cycles and hydrological cycles.
(4) Maintain the evolutionary potential of species and ecosystems by planning management actions over adequately long time scales.
(5) Accommodate human use and occupancy within the sustainable capacity of ecosystems.

The guiding principles developed by Kaufmann and others (1994) principally address the ecological basis for ecosystem management.

(1) Humans are an integral part of today's ecosystems and depend on natural ecosystems for survival and welfare; ecosystems must be sustained for the long-term well-being of humans and other forms of life.
(2) In ecosystems, the potential exists for all biotic and abiotic elements to be present with sufficient redundancy at appropriate spatial and temporal scales across the landscape.

(3) Across adequately large areas, ecosystem processes (such as disturbance, succession, evolution, natural extinction, recolonization, fluxes of materials and other stochastic, deterministic and chaotic events) that characterize the variability found in natural ecosystems should be present and functioning.
(4) Human intervention should not impact ecosystem sustainability by destroying or significantly degrading components that affect ecosystem capabilities.
(5) The cumulative effects of human influences, including the production of commodities and services, should maintain resilient ecosystems capable of returning to the natural range of variability if left alone.
(6) Management activities should conserve or restore natural ecosystem disturbance patterns.

Ecological Approach

Adaptive Management in an Invention Laboratory

The national policy provides little detail in terms of precisely how ecosystem management should be implemented. Agency intent is that the National Forests and Grasslands will serve as invention laboratories that practice adaptive management. Adaptive management is a self-correcting course of action, wherein management activities are planned, implemented and then carefully monitored to discern their effects on the ecosystem. These management activities serve as operational "experiments" and are planned and conducted in close cooperation with National Forest staff scientists and/or Experiment Station research scientists with technical expertise appropriate to the social, biological and physical questions needing investigation. Lessons learned from such studies will then serve as the basis for guiding future management actions.

In fulfilling our role as an invention laboratory using adaptive management, the Arapaho and Roosevelt National Forests and Pawnee National Grassland have developed an implementation strategy to serve as a general framework for ecosystem management. The strategy combines perspectives from the social and natural sciences in support of our agency policy. This strategy is not the final word in ecosystem management, as it will also evolve along with other programmatic aspects under our course of adaptive management. It will, however, serve as a starting point for action and for the continuing discussion of our mission and direction.

Broadening Our Stewardship Responsibility

Shift in Philosophy

Ecosystem management represents a shift in philosophy (Table 1) from one that has been primarily utilitarian (use oriented) to one that is fundamentally ecological (sustainability oriented). The utilitarian view emphasizes only

those parts of the ecosystem (reductionist) that are of direct economic use. The ecological view is concerned with the entire ecosystem (holistic) and recognizes the value in all its components. The ecological view recognizes the dynamic nature of ecosystems and accounts for the range of variation inherent in numerous ecosystem processes and structures. The ecological view also appreciates that numerous outputs of direct economic value to humans are sustained by organisms, structures and processes which operate at levels of scale not readily recognized by many people. The ecological view places primary emphasis on maintaining ecosystem health, integrity, resiliency and sustaining long-term benefits, rather than focusing only on short-term production goals. The ecological view also recognizes that economic outputs are not ends in themselves, but rather byproducts of wise management.

Table 1. A comparison of utilitarian and ecological philosophies.

	Utilitarian	Ecological
Dominant Emphasis:	Resource use	Ecosystem sustainability
Scientific Orientation:	Agronomic = Understanding the basis of production	Ecological = Understanding relationships among organisms and their various environments
Paradigm (= model):	Static; Reductionist = Examining certain individual parts of the ecosystem	Dynamic; Holistic = Examining the entire ecosystem as an interactive whole
What is Important:	Materials of direct economic use	All physical and biological components of the ecosystem
What is Valued:	Extrinsic properties	Intrinsic and extrinsic properties
Timeframe Focus:	Short-term	Short-term and long-term
Output Emphasis:	Production of outputs of economic value	Outputs as byproducts of wise management
Role of Humans:	Dominant species with right to use resources however is wished	A member of the community of living creatures that share numerous ecosystems
Goal of Management:	Maintaining levels of amenity and commodity production that satisfy human desires	Maintaining the health, integrity and resiliency of the ecosystem, as the basic life support system

Agency Managers as Stewards

Ecosystem management is essentially a translation of the ecological view into pragmatic application and requires that managers and scientists take a broader view of their stewardship responsibilities. In addition to resources of direct economic interest, stewardship responsibility is extended to numerous organisms, structures and processes existing at various scales upon which the continuing health of the ecosystem and the sustainable production of useable goods depend. Research and management activities will be broadened to include a greater understanding of "non-economic" entities. Each ecosystem component is respected as possessing intrinsic value, as well as appreciated for its existing (or potential) extrinsic value that is important in the human economy. As the dominant species, humans are an influential component of ecosystems and meeting their legitimate resource needs is an important part of ecosystem management. The essence of ecosystem management is to sustain sociobiophysical systems (Slocombe 1993).

Stakeholders as Stewards

The broader view central to ecosystem management also includes a greater and more effective role for members of the public (stakeholders) to participate in agency planning and decision-making processes. Such an approach requires that greater effort be made to define our numerous publics and assess their needs and desires with respect to the many values provided by public lands. Within the sustainable capacity of ecosystems, public needs will be met by seeking equity among numerous groups, balancing among conflicting interests and weighing present needs with future options.

Management Priorities

In application, ecosystem management is the skillful direction of human activity which ensures resource use at levels that will maintain healthy ecosystems that serve as a sustainable life support system which meets the short-term and long-term needs of humans and other organisms. Ecosystem Management:

(1) Moves beyond managing only those parts of the ecosystem in which humans have a direct economic interest.
(2) Acknowledges that all life forms have value and they, along with ecological processes, contribute to maintaining healthy ecosystems.
(3) Recognizes the need to manage holistically at multiple spatial and temporal scales.
(4) Appreciates the need to develop databases of greater breadth and depth, as a means of assuring information adequacy and accuracy in support of better informed management decisions.
(5) Recognizes the importance of developing partnerships with cooperators in both the public and private sectors, to improve the effectiveness with which shared goals are successfully achieved.
(6) Identifies maintaining ecosystem health as the highest priority, to ensure the long-term sustainability of sociobiophysical systems.

(7) Acknowledges that healthy ecosystems also provide the widest array of options for meeting the present and future needs of the human economy.
(8) Appreciates that maintaining ecosystem health, integrity and resiliency, ensures conditions suitable for the continuing prosperity of our society and social evolution of our culture.
(9) Recognizes that the degree to which ecosystems properly function, as the basic life support system, determines the well being of all life forms, including humans.
(10) Is an approach essential for the continuing long-term viability of our own human species.

Biophysical Dimensions

The biophysical dimensions of our environment represent the fundamental framework of ecological structures and processes that shaped the course of organic evolution. These biophysical factors have also affected humans and continue to influence the course of social evolution by providing the broader context that substantively supports human society. Stewardship of the biophysical environment is, therefore, essential to sustaining sociobiophysical systems. Toward this goal, several key areas are recognized as essential portions of our ecosystem management strategy.

Environmental Protection

Protecting environmental quality of physical resources is fundamental, as these represent the media that support the living community. Management activities will be undertaken in a manner that maintains air quality, water quality, water quantity and the physical, chemical and biological properties of soils. Solid and hazardous wastes will be managed in an environmentally safe manner, in coordination with other federal and state agencies, under the appropriate statutory authorities.

Conservation of Biological Diversity

Conserving biological diversity is also fundamental, as it is the assemblage of genotypes, species and communities that constitute the variety of living components that play a critical role in maintaining ecosystem health through stabilizing atmospheric composition, amelioration of global climate, water purification, flood control, soil formation and stabilization, creation of habitat and production of useable biomass. Wild populations also serve as potential sources of valuable genetic material, medicines, energy and raw materials for industry.

In application, conservation of biological diversity is primarily concerned with rarity, vulnerability, viability and ensuring that reductions in species or community diversity do not bring about population declines to levels that would threaten their continued existence. In pursuing this goal, a "fine-filter" approach will be undertaken, one that focuses upon individual species that are currently endangered or threatened and those which may be potentially endangered or threatened, such as sensitive species. Efforts will be

undertaken to improve our knowledge of such species and integrate their needs into more holistic management programs.

In pursuing the larger scale goal of conserving biotic communities, landscapes and ecosystems which may be declining or poorly represented, a "coarse-filter" approach will be undertaken. This effort will focus on maintaining within the larger matrix an array of representative ecosystems adequate to perpetuate a large portion of the component species. Attributes such as composition, structure, processes, interior species, keystone species and minimum viable area will need be described for the full array of communities and landscapes.

A greater understanding of the ways in which natural disturbances and human actions have affected ecosystems in the past is vital and efforts to improve our knowledge of the historic variation (i.e., natural range of variability) of numerous ecosystem attributes will be undertaken. In remediation of certain undesired results of past human actions (e.g., shift in species composition, change in age-class structure or habitat fragmentation), appropriate restoration efforts may be necessary, including the reintroduction of missing species. Managers will acquire an improved understanding of which management activities are compatible with maintaining biological diversity at these various levels of scale.

Sustainable Production

Sustaining biological production is fundamental to maintaining ecosystem health and integrity, as well as contributing to human economic prosperity. Biological production is a continuously ongoing natural process in all ecosystems. If the above objectives of protecting the physical environment and conserving biological diversity are achieved through wise management, the natural productive potential of an ecosystem is normally realized.

Humans have a relatively limited ability to increase ecosystem production levels above the native potential. However, they can significantly depress ecosystem productivity by contributing to environmental degradation (e.g., soil loss). Endeavors such as agriculture, silviculture, range management and wildlife management have not substantially increased the productivity of ecosystems. Rather, they have modified ecosystem attributes like species composition and structure so that a greater proportion of biological production is captured by species favored for economic reasons. Energy and nutrients thus channeled to favored species are unavailable for assimilation by others.

The essence of achieving sustainable biological production with respect to resources useable by humans, is to extract quantities (i.e., energy, nutrients and water) at rates that are naturally replaced, within the native productive capacity of the ecosystem. This necessitates that managers possess inventory databases and production function models that operate at levels of precision adequate to accurately estimate use levels that can be sustained in perpetuity. Sustaining biological production is equally important for resource uses that are non-extractive, as it also supports resource values such as scenic beauty and watchable wildlife. However, for non-extractive

uses it is the ecosystem's ability to recover following perturbation (resiliency) that becomes the variable of interest when developing models which quantify the Limits of Acceptable Change. Sustaining biological production may best be considered in terms of a financial metaphor, which admonishes the investor to live on the interest (surplus) of an investment while protecting the principal (native productive potential).

Maintaining Suitable Habitat

Maintaining habitat of suitable quantity and quality for the major groups of biota (i.e., microbes, plants and animals) is fundamental to successfully managing ecosystems, as it is at the habitat level that all organisms (including humans) directly interact with their environment and derive from it the sustenance necessary for their survival. This does not presuppose that we can prevent the ecological process of species extinction, but rather that our actions will attempt to minimize the adverse influence of human activity upon other species. Sufficient quantities of substrates suitable for important microorganisms (e.g., decomposers, nitrifiers, etc.) will be maintained, which enable these species to complete their life cycles and thereby contribute to overall ecosystem health. Habitat characteristics that allow for continuous establishment, growth and reproduction of all native and desirable exotic plants will be maintained. Habitat for all native and desirable exotic animals will provide suitable areas where reproduction (i.e, mating, birthing, rearing), security (i.e., escaping, hiding, resting, thermal protection) and feeding (i.e., detritivorous, herbivorous, carnivorous) needs can be met. Habitat which meets the non-extractive (i.e., research, recreation), extractive-renewable (i.e., water, fishing, hunting, plant harvesting) and extractive-nonrenewable (i.e., mining, petroleum development) needs of humans will be maintained and, restored where necessary. Maintaining habitat of an appropriate composition, structure and distribution may be one of the most important biophysical dimensions of ecosystem management, for without sufficient amounts of suitable habitat, the viability of individual species cannot be assured. Ecosystem managers will need to remain constantly vigilant in preventing degradation of habitat for a wide variety of organisms.

Human Dimensions

Position and Role of Humans

The extraordinary abilities of Homo sapiens, particularly their mental powers of reason and advanced use of language, have conferred upon them a pre-eminent position that is completely unique on this planet. The human species has ascended through evolution and competition to a place of overall dominance, whereby every ecosystem on Earth is now either affected by or under their direct influence. Nonetheless, humans, like all other species, are an integral part of the ecosystems they inhabit, which they continue to shape and which have historically shaped them. This dominant position confers upon humans an ethical obligation for the sake of all species to practice responsible stewardship and wise management that will not harm, but rather sustain our planet's sociobiophysical systems.

To understand the role of humans as an important species of the ecosystem, it is essential to ascertain the diversity of human values, beliefs, perceptions, attitudes, behaviors and needs. Not only should these be understood from a physiological standpoint (i.e., basic needs), they should also be appreciated from the perspective that is unique to the culture of each human society (i.e., psychological and spiritual). Cultural understanding and appreciation will take on increasing importance as American society becomes more culturally diverse in the future. Also, cultural beliefs evolve and societal values change through time. Such social evolution has been a contributing cause to the recent movement toward ecosystem management.

Meeting Human Needs

As the Forest Service implements ecosystem management, meeting human needs within ecosystem limitations will be an important part of the agency mission. Human needs of the present generation will be met in a manner which also maintains options for meeting the needs of future generations. Present needs will be met in a way that equitably apportions resources among competing public interests. Public participation in planning and implementation decisions will be improved so as to better serve the numerous publics that depend upon federal lands for a wide variety of goods, services and values. Implementation of ecosystem management will encourage development of improved

(1) Understanding of historical patterns of land and resource use.
(2) Appreciation for human perceptions of condition, utility and function.
(3) Awareness of social, cultural and demographic conditions.
(4) Understanding of management mandates, goals and constraints.
(5) Insight concerning human needs, demands and desires relative to economic, recreational, educational and spiritual values.
(6) Knowledge of the positive and negative ways in which human interaction with the ecosystem influences its health, integrity, resiliency and its ability to produce outputs which sustain our sociobiophysical systems.

Forest Strategy for Implementation

Public Participation

While planning for ecosystem management occurs at many levels, it is at the forest and district levels where most resource allocation decisions are made that directly effect the lives of people. It is therefore essential that effective public participation be an important component of developing the forest plan and district plans for implementation of ecosystem management programs and projects. Members of the public representing a wide variety of interests and viewpoints will be welcomed as key stakeholders and important partners in fashioning plans that reflect the goals of ecosystem management. Close positive working relationships will be maintained with other agencies at all levels of government and all interested publics as ongoing cooperators in planning and implementation activities.

Ecological Classification and Inventory

Recognizing that traditional single resource inventories have limited utility in addressing complex ecosystem management questions, an ecological classification system based upon a multi-factor approach has been adopted (USDA Forest Service 1993). This system classifies ecosystems broadly by climate at upper levels of the hierarchy (domain, division) and by landforms and vegetation at progressively lower levels (province, section, subsection). This "top-down" methodology is quite effective for developing ecosystem maps useful in multi-forest, multi-agency and statewide strategic planning. However, below the subsection level, more specific "bottom-up" ecological information gathered from field surveys is needed to construct lower levels (landtype association, landtype, landtype phase) of the classification.

Once landtype data has been distilled into an ecological classification for a specific forest, maps of suitable scale and detail can then be developed which will serve forest-level and district-level ecosystem management planning and implementation needs. The classification of ecological landtypes allows for stratification of the forest landbase into units of similar productive capacity and similar response to specific management treatments. Mapping ecological landtypes provides a visual display of their occurrence across the landscape and greatly enhances strategic forest planning, project planning, project implementation, monitoring design and evaluation efforts. As a fundamental framework for ecosystem management, this ecological classification system not only provides assistance to managers of federal lands, but also provides useful insights for managers of adjacent non-federal lands.

Implementation Process Overview

Within the general guidance of the forest plan, desired conditions for each geographic area will be developed with assistance from the landscape analysis and design process. Project planning on individual districts will then identify a series of management activities required to attain and/or maintain desired conditions. Individual projects will then be implemented through the adaptive management process to tangibly affect present ecosystems and shape the character of future ecosystems. Success in achieving objectives will then be measured through efforts which monitor and evaluate the individual and cumulative changes of specific ecosystem attributes.

Attaining Desired Conditions in Geographic Areas

Delineation of Geographic Areas

Geographic areas will be identified as subdivisions of each district of the national forests and grassland. These geographic areas will be delineated in accordance with principal watersheds or other ecological features (i.e., landforms, soils, vegetation) present across the landscape. These areas will serve as an "on-the-ground" implementation framework for ecosystem management, especially at the local level. It is essential that delineation of these

areas consider the patterns of ownership and management of adjacent non-federal lands.

Desired Condition Statement

For each geographic area, a desired condition statement will then be prepared, which will describe the major composition, structure, pattern and process attributes of the geographic area that managers wish to attain or maintain. Generally, the desired condition will identify conditions within ecosystems of the specific geographic area that are considered desirable from the standpoint of contributing to the sustainability of sociobiophysical systems in the locale and region. The desired condition statement should define physical characteristics (e.g., landforms, water, roads, etc.), biological attributes (e.g., plant communities, animal populations, habitat structure, etc.) and future uses of the geographic area at a future point in time (50 years or more). The landscape analysis and design process of Diaz and Apostol (1992) discussed below will be used to develop the desired condition statement.

Existing Condition Statement

For each geographic area, an existing condition statement will also be written that describes its existing composition, structure, pattern and process attributes. The existing condition will identify conditions within the ecosystems of the specific geographic area as they exist at present. The existing condition statement will define physical characteristics, biological attributes, historical uses (by aboriginal and immigrant peoples) and current uses.

Disparity Assessment

Then for each geographic area, managers will conduct a disparity assessment, which identifies disparities between the existing and desired conditions. From this process, managers will then identify opportunities for management activities that will change the state of ecosystems in each geographic area from the existing condition closer to the desired condition. A list of proposed management activities will be prepared and arranged in a time sequence appropriate for implementation. The proposed management activities may also include changes in current activities or discontinuation of current activities identified as not contributing to attaining or maintaining the desired condition.

Implementation Strategy

The final proposed management activities list ultimately becomes the ecosystem management implementation strategy for achieving the desired condition within a geographic area. The ecosystem management implementation strategy for each geographic area should be coordinated with those of adjacent geographic areas, to prevent potential conflicts and incongruities in management objectives. In addition, ecosystem implementation strategies for individual geographic areas should be included in cumulative effects analyses, which will identify large-scale and long-term problems that may be undetected by short-term analyses at

local-scales. Properties that emerge at these higher scales of analysis can then be incorporated into strategies which address more complex and difficult management questions. The resulting ecosystem management implementation strategy will then represent a strategic approach to management that is spatially (i.e., site, watershed, landscape, ecoregion) and temporally (i.e., short-term, long-term) integrated across a hierarchy of multiple scales and has great utility to numerous administrative subdivisions (i.e., district, forest, region).

Transdisciplinary Integration

The importance of integration among disciplines cannot be overemphasized, when planning projects that comprise the implementation strategy. Difficulties with the interdisciplinary team approach have arisen in the past, when members practicing single resource advocacy impeded the process. While critical review and honest debate are essential to good planning, it is crucial to sound ecosystem management that individual disciplines not practice single resource advocacy. Rather, an approach termed transdisciplinary is more appropriate to this endeavor (Slocombe 1993). While each member provides their individual expertise, all transdisciplinary team members will serve as advocates for the entire ecosystem and are collectively responsible for management of all its components, from the very largest to the very smallest. The transdisciplinary team approach will ensure that resource use by humans sustains all of the biological and physical components essential to maintaining ecosystem health.

Monitoring and Evaluation

In recognition that our knowledge about ecosystems is incomplete and the outcomes of management actions are often uncertain, ecosystem management can be successfully implemented only through the process of adaptive management. Adaptive management is a self-correcting process wherein each management action (treatment) is regarded as an operational experiment designed to test a working hypothesis (proposition) concerning the manner in which ecosystems are likely to respond (effects). Essential to adaptive management is the process of monitoring, i.e., the collection of pretreatment and post-treatment data from plots within experimental (treated) and control (untreated) areas. Monitoring data is then evaluated in various ways, (e.g., comparison with established standards, analysis of variance, simple correlation, time-series analysis, etc.) which reveal the significant effects of the operational treatment. Cause-and-effect knowledge gained through this process then serves as valuable feedback to assist managers in modifying or updating operational procedures for managing the ecosystem. Monitoring and evaluation represents one important area for sharing of scientific skills between Research Station scientists and those in the National Forest System.

The monitoring and evaluation program can be structured to measure the (1) ecological change occurring in various ecosystems and (2) degree to which desired conditions are attained within geographic areas, as well as track administrative compliance with the forest plan by determining whether (3) standards and guidelines are met and (4) sustainable output goals have been

achieved. Ecological change (part 1) could be monitored by establishing a well designed network of long-term plots in various ecosystems. Ecosystem status (part 2) could be assessed by periodically estimating the proportion of each geographic area that has attained its desired condition (either on a process or areal basis). Environmental protection and biological conservation (part 3) could be ascertained by determining the degree to which or portion of the landscape over which standards and guidelines for air quality, water quality, water quantity, soil productivity, species and community diversity, population viability, landscape pattern (structural diversity and spatial distribution) and ecological processes have been met. Sustainable output goals (part 4) could be measured by periodically summarizing commodities produced and amenities provided in direct service to humans.

Landscape Analysis and Design

Landscape analysis and design is basically a process for developing a target landscape pattern for a specific geographic area (Diaz and Apostol 1992). Thus, it is an essential part of developing a desired condition as discussed above. This process is similar to existing Integrated Resource Analysis; however, it uses different information and a different focus which leads to a more holistic view of the landscape as an ecosystem. Innovations include

(1) Resources are integrated rather than considered separately at the design phase (They may or may not be considered separately in the analysis phase).
(2) The focus is on the landscape as an ecological system, emphasizing the relationship between structure and function.
(3) Objectives (desired conditions) are stated in terms of landscape elements, functions and patterns, NOT as individual resource objectives (i.e., levels or kinds of uses).
(4) The existing condition of the landscape pattern does not necessarily circumscribe the "target" landscape pattern.

The landscape analysis and design process consists of

Steps 1 through 5: Understanding the landscape as an ecological system, in terms of composition, structure, function, processes and context within the larger landscape.

Step 6: Identifying existing policies regarding landscape pattern and objectives.

Steps 7 and 8: Combining knowledge of the landscape ecosystem, existing policies and local concerns to describe and spatially array the landscape pattern that individual projects will create.

Analysis Phase -- Understanding the Ecological System

Step 1 - Landscape Elements: The process begins with identification and mapping of landscape elements (i.e., patches, corridors and matrix) and the landscape pattern. Determining the scale that will be used for analysis is important. It is also helpful to view the process of delineating landscape structures in terms identifying areas that are homogeneous with regard to plant community or ecosystem type, stage of succession or stability, within-patch structure, ecological capability or productivity and origin of patches. The overall matrix is described in terms of the variety in plant community composition, structure and pattern in relation to physiographic features of the landscape. Patch types and patterns are identified. Corridors types, such as roads, trails, utility rights-of-way and riparian zones, are located.

Step 2 - Landscape Flows: Ecosystem components of interest or concern, which flow across the landscape, are identified and mapped. These flow phenomena are those things which move across or through landscapes, whether in the air, over the land or in the soil. They may be material or energy flows. Wind, water, fire, plants (as seeds), animals and humans are typical ecosystem components that may flow across a landscape. The most important flows to the manager are those which are critical to the functioning of a particular landscape and those which are most likely to be affected by human activity. It is important to identify where in the landscape that a particular flow occurs, the direction typically taken by the flow and the timing of the flow.

Step 3 - Relation between Landscape Elements and Flows: Interactions between the elements/pattern and flows are then described, to improve understanding of the functional dynamics of the landscape. This is done by constructing a table that arrays landscape elements on the vertical axis and landscape flows on the horizontal axis and describing the ways in which each element interacts with each flow to either foster, inhibit, increase, decrease, direct, alter, compete or synergistically react. While complete knowledge of every possible interaction is unlikely, it is essential that all that is known be incorporated into this interactions table.

Step 4 - Natural Disturbances and Succession: Natural disturbances and successional processes are next described, to highlight how they affect and are affected by landscape patterns. The agents of change that would exist in the natural ecosystem are first identified. These agents may include fire, wind, insects, pathogens, landslides and other phenomena. The effects of each agent on the landscape pattern (arrangement, composition, size and shape of patches; connectivity; matrix characteristics) are next described. It is useful to develop information concerning the type of effect, intensity, frequency, duration and areal extent of each disturbance. Then, the natural landscape patterns are analyzed to determine their influence upon the behavior of disturbance phenomena. It is important to understand the successional sequences (trajectories of change through time) in plant communities occupying the landscape and how each type of disturbance influences the rate and direction of their progression.

Step 5 - Linkages: Functional linkages to adjacent geographic areas are finally described. Initially, it is important to understand how processes within the geographic area are linked to the larger landscape beyond. Flow phenomena which interact with areas outside the geographic area are first identified. Then, landscape elements which contribute to or otherwise interact with these flow phenomena are described. Secondly, it is important to appreciate how landscape elements within the geographic area are related to those in the larger landscape beyond. Existing islands of unfragmented habitat, migration routes, riparian corridors and nodal networks both within and beyond the geographic area are identified. These interrelated structures are then analyzed to determine their importance.

Design Phase -- Establishing Objectives

Step 6 - Landscape Patterns from the Forest Plan: Existing landscape pattern objectives are next determined by consulting the forest plan. Management direction in the plan (e.g., Standards and Guidelines, Management Area prescriptions, etc.) typically does not specify a landscape pattern for each geographic area. However, information such as specifications for vegetation patch size and dispersal, high priority flow phenomena (i.e., elk, deer, recreation along rivers), visual quality objectives, recreation opportunity spectrum and statements concerning plant composition, age-class structure and wildlife habitat categories (thermal cover, forage, openings) is usually relevant. When the Plan is relatively vague concerning direction for a specific geographic area, greater latitude is afforded the manager in designing a target landscape that reflects desired conditions.

Step 7 - Narrative of Landscape Pattern Objectives: Statements that describe the target landscape pattern (kinds, shapes, sizes, arrangement of landscape structures) in various portions of the geographic area are then developed, using information from the Analysis Phase (steps 1 through 5) and the resource management objectives specific to the locale (from step 6). Once important landscape functions and resource issues are identified, information from the Analysis Phase is used to determine what landscape elements and patterns are needed to provide for them. This may include information about rare, unusual, critical or unique landscape elements (i.e., wetlands, corridors, old-growth), elements which require restoration (i.e., species reintroduction), processes which need re-establishment (i.e., periodic fire) and patterns which require modification (i.e., fragmented habitats, edges, patch size and dispersal). It is important to recognize that design is a highly subjective process, with no single design a perfect solution to all issues. It is also important to note that this step does not involve making allocation decisions.

Design Phase -- Developing the Spatial Pattern

Step 8 - Landscape Design: Finally, the geographic area within which a particular landscape pattern is desired (based on the objective statements from step 7) is mapped using techniques of landform analysis and spatial design. This is where the target landscape described in Step 7 is given spatial form in the context of actual landforms. At this point, design progresses beyond planning, into the realm of deliberately creating a three-

dimensional landscape pattern. The goal is to describe the relationship of future vegetation patterns to landforms, develop a conceptual circulation system and fit the overall program to the landscape in a way that allows it to be visualized, mapped and described. A landform analysis is conducted by analyzing topography as a means of developing a three-dimensional model of the landscape. The topography of landforms has a strong influence upon flows in the operational environment of the landscape. Several opportunities and constraints maps are then prepared to display various options for the spatial location of elements in the landscape. Once a conceptual design is agreed upon by managers and stakeholders, additional detail is incorporated into the selected design. It is essential that elements and flows of human as well as natural origin be incorporated into the design of this target landscape which reflects desired conditions.

Uses of the Target Design

The fully developed target landscape design for the geographic area may then be used for several purposes. The landscape design may serve as the basis for generating proposals for individual projects, which will move the geographic area closer to its desired condition. The design may become the basis for evaluating the potential effects of proposed projects on landscape level phenomena. It may also act as a tool for communicating with the public about how implementation of proposed projects will effect aesthetic attributes and ecological processes.

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